US 20120039046A1

(19) **United States**
(12) **Patent Application Publication**
BEAUMIER et al.
(10) **Pub. No.: US 2012/0039046 A1**
(43) **Pub. Date: Feb. 16, 2012**

(54) **MULTICHIP ELECTRONIC PACKAGES AND METHODS OF MANUFACTURE**

(75) Inventors: **Martin M. BEAUMIER**, Quebec (CA); **Steven P. OSTRANDER**, Hopewell Junction, NY (US); **Kamal K. SIKKA**, Hopewell Junction, NY (US); **Hilton T. TOY**, Hopewell Junction, NY (US); **Jeffrey A. ZITZ**, Hopewell Junction, NY (US)

(73) Assignee: **INTERNATIONAL BUSINESS MACHINES CORPORATION**, Armonk, NY (US)

(21) Appl. No.: **12/856,699**

(22) Filed: **Aug. 16, 2010**

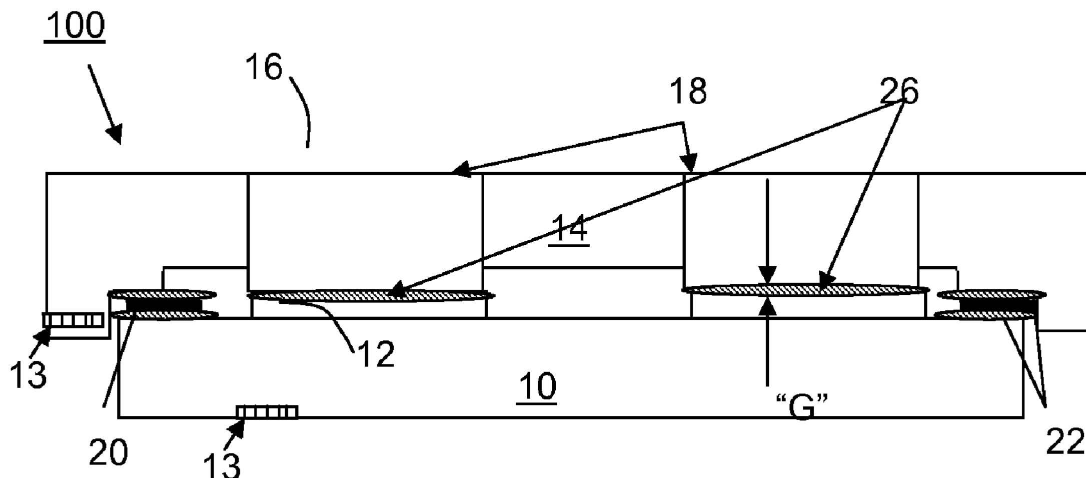
Publication Classification

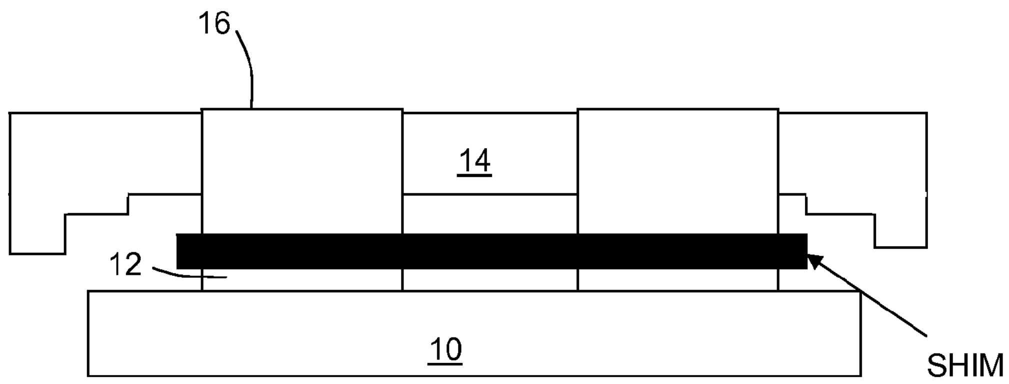
(51) **Int. Cl.**
H05K 7/20 (2006.01)
B23P 11/00 (2006.01)

(52) **U.S. Cl.** **361/714**; 29/428

(57) **ABSTRACT**

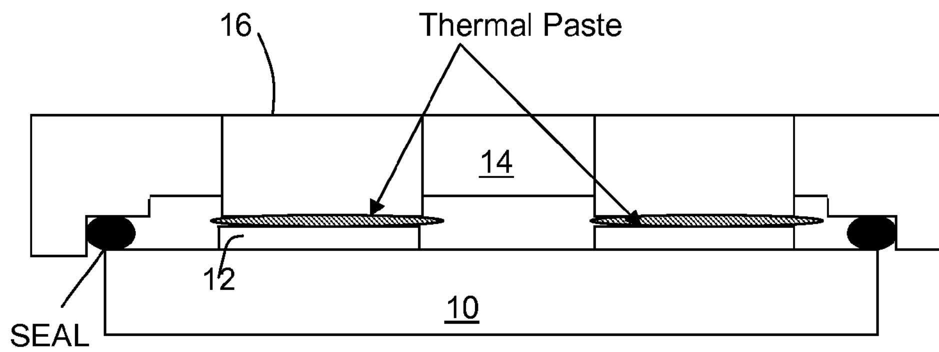
A multi-chip electronic package and methods of manufacture are provided. The method includes contacting pistons of a lid with respective ones of chips on a chip carrier. The method further includes separating the lid and the chip carrier and placing at least one seal shim on one of the lid and chip carrier. The at least one seal shim has a thickness that results in a gap between the pistons with the respective ones of the chips on the chip carrier. The method further includes dispensing thermal interface material within the gap and in contact with the chips. The method further includes sealing the lid to the chip carrier with the at least one seal shim between the lid and the chip carrier.





"Prior Art"

FIG. 1a



"Prior Art"

FIG. 1b

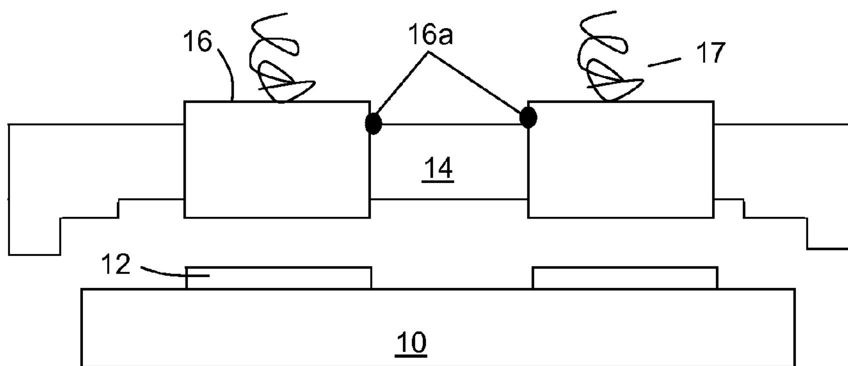


FIG. 2

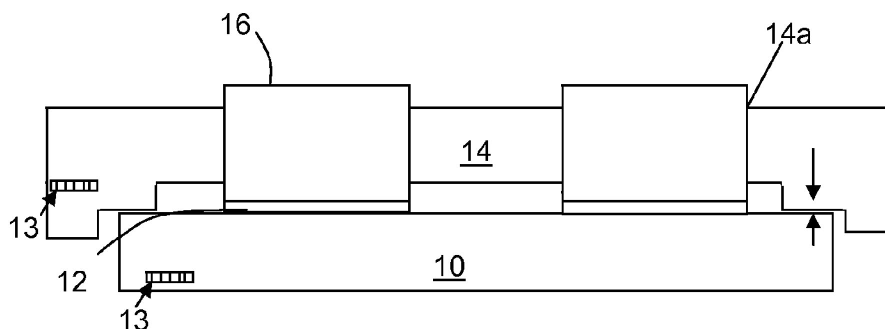


FIG. 3

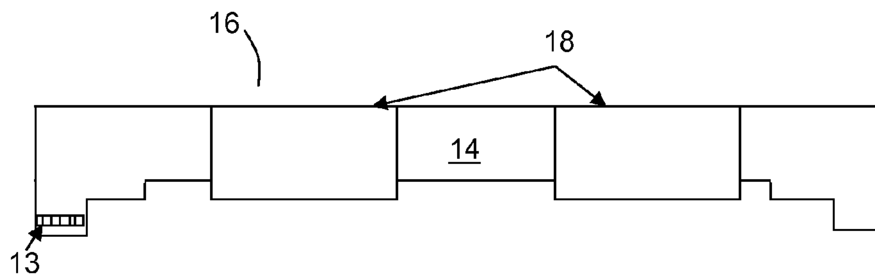


FIG. 4

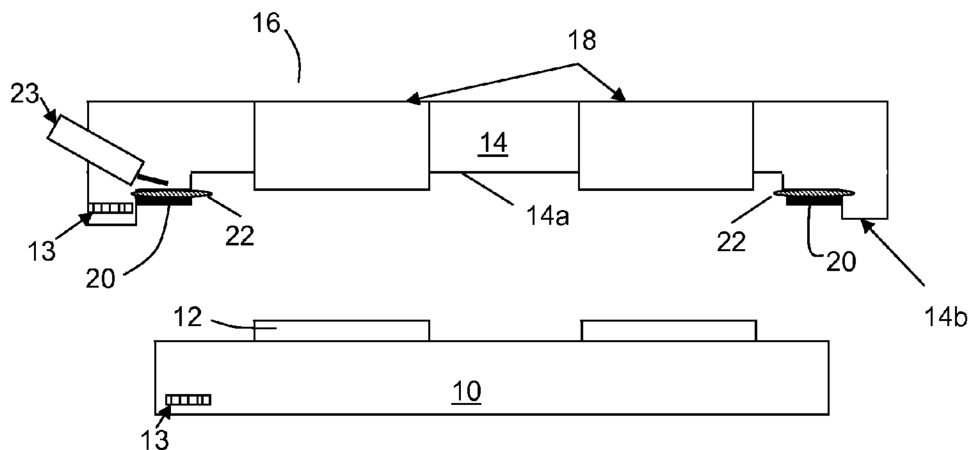


FIG. 5a

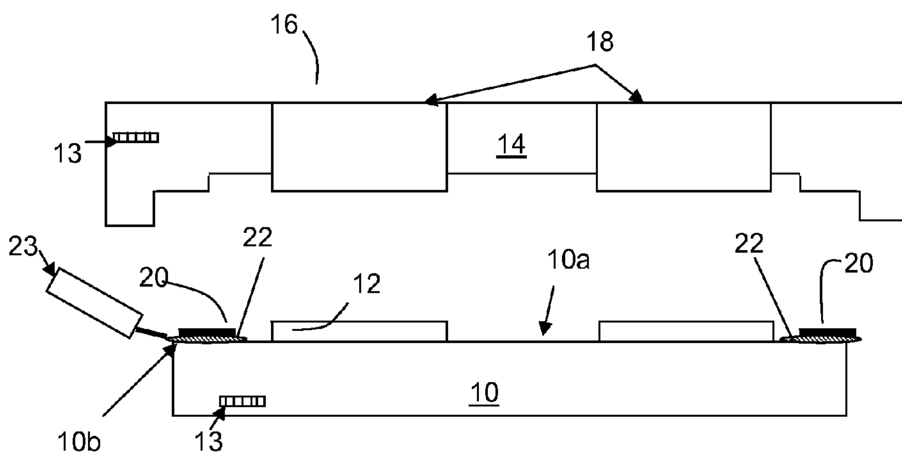


FIG. 5b

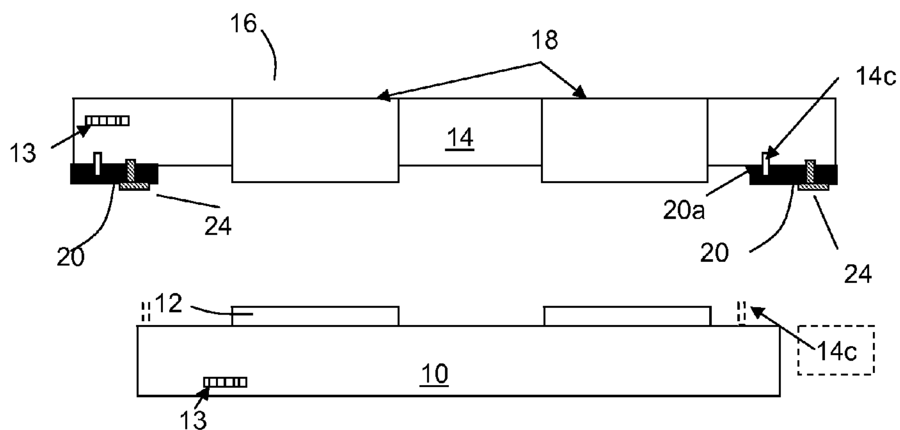


FIG. 5c

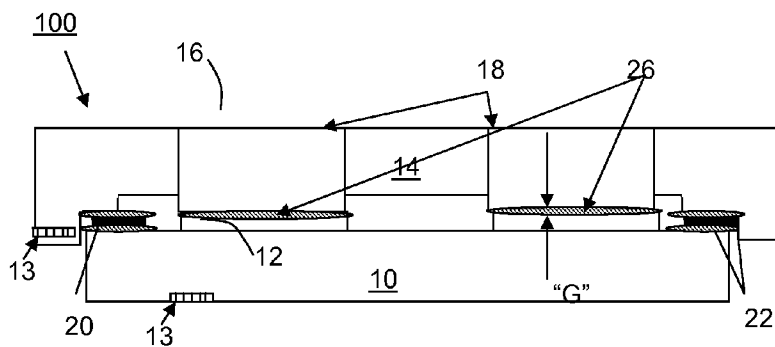


FIG. 6

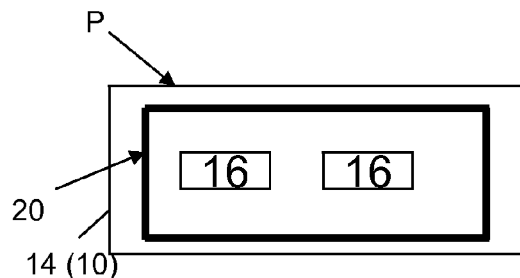


FIG. 7a

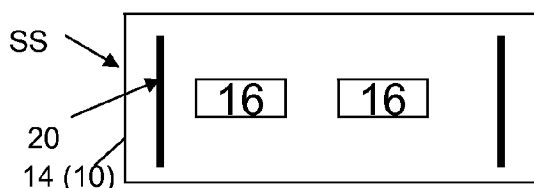


FIG. 7b

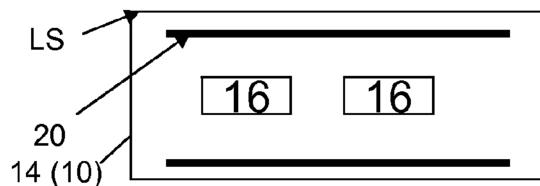


FIG. 7c

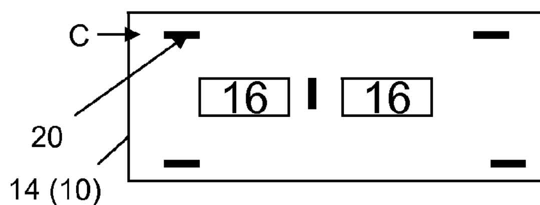


FIG. 7d

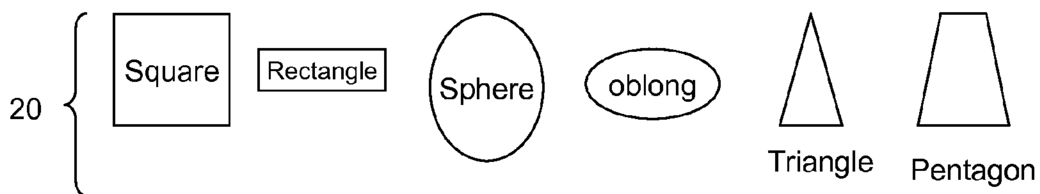


FIG. 8

MULTICHIP ELECTRONIC PACKAGES AND METHODS OF MANUFACTURE

FIELD OF THE INVENTION

[0001] The invention relates to semiconductor package structures and methods of manufacture and, more particularly, to multi-chip electronic packages and methods of manufacture.

BACKGROUND

[0002] Thermal management of multi-chip electronic packages is critical to ideal performance of the multi-chip electronic packages. Currently, multi-chip electronic packages encapsulate chips between a lid and chip carrier by forming a customized gap between pistons of the lid and the chips mounted on the chip carrier, and dispensing a thermal interface material (TIM) within the gap. The gap is formed by the use of a chip shim placed between pistons of the lid and the chips of the multi-chip electronic packages.

[0003] Referring to FIGS. **1***a* and **1***b*, a plurality of chips **12** are shown attached to a chip carrier **10**. During assembly, a chip shim is placed between the pistons **16** and chip **12** in order to form a gap between the pistons **16** and the chips **12** (FIG. **1***a*). A lid or hat **14** (hereinafter referred to as a lid) is positioned over the chip carrier **10**. The lid has "pistons" **16** that are moved such that they contact the chip shim. The lid is then removed from the chip carrier **10**, and the pistons **16** are fixedly attached to the lid **14**. The chip shim is removed and the thermal interface material is then placed on the chips. Once the thermal interface material is on the chips **12**, the chip carrier **10** and lid are sealed to one another in order to encapsulate the chips **12** (FIG. **1***b*).

[0004] The chip shim needs to retain flexibility to conform to the chip surfaces; however, this becomes increasingly more difficult with the increasing number of chips on the package. In fact, it also becomes difficult to use the chip shims when other components or features are placed between the chips. Also, using the chip shim increases production costs due to the complexity of conforming the chip shim to the features of the chip and other components on the chip carrier, as well as the cost of the chip shim, itself.

[0005] Accordingly, there exists a need in the art to overcome the deficiencies and limitations described hereinabove.

SUMMARY

[0006] In a first aspect of the invention, a method comprises contacting pistons of a lid with respective ones of chips on a chip carrier. The method further comprises separating the lid and the chip carrier and placing at least one seal shim on one of the lid and chip carrier. The at least one seal shim has a thickness that results in a gap between the pistons with the respective ones of the chips on the chip carrier. The method further comprises dispensing thermal interface material within the gap and in contact with the chips. The method further comprises sealing the lid to the chip carrier with the at least one seal shim between the lid and the chip carrier.

[0007] In another aspect of the invention, a method comprises placing a lid and chip carrier in proximity to one another such that pistons of the lid are in registration with chips on the chip carrier. The method further comprises contacting the pistons of the lid with respective ones of chips on the chip carrier. The method further comprises moving apart the lid and chip carrier. The method further comprises attaching at least one seal shim to the lid or the chip carrier which, when the lid and chip carrier are attached to one another, form a gap between the pistons with the respective ones of the chips. The method further comprises dispensing thermal interface material within the gap after the attaching of the seal shim. The method further comprises sealing the lid to the chip carrier with the at least one seal shim between the lid and the chip carrier.

[0008] In yet another aspect of the invention, a structure comprises a lid encapsulating at least one chip mounted on a chip carrier. The structure further comprises at least one seal shim fixed between the lid and the chip carrier. The at least one seal shim forms a gap between the pistons of the lid and respective ones of the chips. The structure further comprises dispensing thermal interface material within the gap and contacting the pistons of the lid and respective ones of the chips.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0009] The present invention is described in the detailed description which follows, in reference to the noted plurality of drawings by way of non-limiting examples of exemplary embodiments of the present invention.

[0010] FIGS. **1***a* and **1***b* show conventional multi-chip electronic packages and methods of manufacture;

[0011] FIGS. **2**-**4**, **5***a*, **5***b*, **5***c*, and **6** show stages of fabricating multi-chip electronic packages in accordance with aspects of the present invention;

[0012] FIGS. **7***a*-**7***d* show several exemplary arrangements and configurations of seal shims used in the multi-chip electronic packages in accordance with aspects of the present invention; and

[0013] FIG. **8** shows cross sectional views of seal shims used in the multi-chip electronic packages in accordance with aspects of the present invention.

DETAILED DESCRIPTION

[0014] The invention relates to semiconductor structures and methods of manufacture and, more particularly, to multi-chip electronic packages and methods of manufacture. More specifically, the present invention addresses the thermal management design of multi-chip electronic packages by using a seal shim to provide a gap for thermal interface material (TIM) provided between a lid and chips (mounted on a chip carrier) of the multi-chip electronic packages; compared to a chip shim that is used to determine a gap between a lid and the chips of the multi-chip electronic packages.

[0015] The thickness dimension of the seal shim and sealing material will result in a gap for the TIM. For example, in embodiments, the gap required between the lid and the chips is made by placing the seal shim between the lid and the chip carrier, in addition to sealing material. In embodiments, the seal shim is attached to the lid by a polymer seal, adhesive, epoxy of other substance, or mechanical fasteners (prior to TIM dispense). In further embodiments, the seal shim can be attached to the chip carrier by use of a polymer seal, adhesive, epoxy of other bonding substance. The TIM can be dispensed on the chips at the same time as attaching the seal shim to the lid or the chip carrier, or the seal shim can be attached prior to dispensing of the TIM.

[0016] FIG. **2** shows a beginning process and related structures in accordance with aspects of the invention. More specifically, FIG. **2** shows a plurality of chips **12** attached to a

chip carrier **10**. A lid or hat **14** (hereinafter referred to as a lid) is positioned over the chip carrier **10** such that "pistons" **16** are aligned (registered) with each of the chips **12**, respectively. The pistons **16** can be releasably attached to the lid **14** by many different methods as shown by reference numeral **16***a*. For example, the pistons **16** can be soldered to the lid **14** by solder, or attached by an epoxy of other adhesive. In embodiments, the pistons **16** can be made from copper, for example, and should have a same or substantially same footprint as the chips **12**. Advantageously, the method and structure of the present invention is customizable for chips of different sizes (e.g., different thickness), shapes, and power levels. The pistons **16** can be spring loaded into the lid **14** using springs or other resilient mechanisms **17** of a fixture or mechanism attached to lid **14**.

[0017] In FIG. **3**, in embodiments, the lid **14** and/or the chip carrier **10** can be moved in close proximity to one another. The "pistons" **16** should be aligned (registered) with each of the chips **12**, respectively. Once the lid **14** and/or the chip carrier **10** are in close proximity to one another and the pistons **16** and chips **12** aligned, the pistons **16** are released in order to come into direct contact with the chips **12**. This will result in a "0" gap between the pistons **16** and the chips **12**, which will ensure a precise thermal gap between the pistons **16** and chips **12** when a seal shim in inserted between the chip carrier **10** and lid **14**, regardless of the variation in height of the chips. That is, the method of the present invention will ensure that there is a uniform thermal gap between each piston **16** and chip **12** for TIM to be dispensed therebetween, regardless of chip variation, as the entire lid will be raised above the chip carrier **10**, with the starting point of the piston **16** be in direct contact with its respective chip **12**. This is in contrast to known methods in which a gap between the pistons **16** and chips **12** is determined by a chip shim.

[0018] The pistons **16** can be released from the lid **14** using many different methods. For example, when the pistons **16** are soldered to the lid **14** by eutectic solder, the entire assembly can be placed in a reflow furnace to bring the solder to a melting point. When the solder reaches its melting point, the pistons **16** will be released and will move into direct contact with the chips **12**. At this stage of processing, for example, the pistons **16** can be forced into direct contact with the chips **12** by the force of the springs or other resilient mechanisms **17** of a fixture or mechanism attached to lid **14**.

[0019] As the assembly cools, the solder will then harden and again fix the pistons **16** to the lid **14**, but now in a lowered position. The position of the pistons **16** are in a final position, with respect to the lid **14**.

[0020] In the case of an adhesive or epoxy or other bonding agent, a chemical solution can be used to release the pistons **16** from the lid **14**. Once the pistons **16** are released, they will move into direct contact with the chips **12**. At this stage of processing, for example, the pistons **16** can be forced into direct contact with the chips **12** by the force of the springs or other resilient mechanisms **17** of a fixture or mechanism attached to lid **14**.

[0021] In this lowered position, the pistons **16** can then be fixed to the lid **14** by, for example, adhesive or epoxy or other bonding agent (including a solder). The position of the pistons **16** are in a final position, with respect to the lid **14**.

[0022] In alternate embodiments, the pistons **16** can be placed into holes **14***a* after the lid **14** and/or the chip carrier **10** are moved in close proximity to one another. In this embodiment, the holes **14***a* are aligned with the chips **12**. Once in alignment, the pistons **16** are placed into the holes **14***a*, and allowed to come into direct physical contact with the chips **12**. Once the pistons **16** are in direct contact with the chips **12**, they can then be fixed or attached to the lid **14** by solder, adhesive, epoxy or other bonding substance.

[0023] Using the embodiments described thus far, the lid **14** and chip carrier **10** are customized for each other. For this reason, the lid **14** and chip carrier **10** combination can be marked by, for example, a bar code or other indicia shown at reference numeral **13** to ensure that the matched lid **14** and chip carrier **10** are attached to one another, in later processing steps, to form a multi-chip electronic package. The bar code or other indicia **13** can provide information about the lid **14** and chip carrier **10**, as well as the thermal interface gap that is created between the pistons **16** and chip **12**, as discussed in further detail below.

[0024] As shown in FIG. **4**, the back side of the pistons **16** can be planarized to a flat surface **18** with the surface of the lid **14**. In embodiments, the planarization can be performed by a mechanical planarization process such as, for example, a grinding or cutting process, well known to those of skill in the art. The planarization allows good thermal contact between the lid and an external cooling device such as a heat sink or cold plate.

[0025] FIGS. **5***a*, **5***b* and **5***c* show different methods of attaching a seal shim **20** to either the lid **14** or chip carrier **10**. The seal shim **20** can be made by many different types of materials such as, for example, stainless steel, brass, plastic or other stable material. As should be understood by those of skill in the art, the seal shim **20** (and sealant **22**) will create a customizable thermal interface gap between the chips **12** and the pistons **16** for TIM to be dispensed therebetween. In embodiments, the thickness of the seal shim **20** and sealant **22** will be equal or substantially equal to the thermal interface gap (shown in FIG. **6** as reference "G") between the chips **12** and the pistons **16** for the placement of the TIM.

[0026] In embodiments, the thermal interface gap "G" is about 25 micrometers to 75 micrometers; although, other dimensions are also contemplated by the present invention. For example, in embodiments, the thermal interface gap "G" can be customized by the thickness of the seal shim **20** and the sealant **22**, where the thickness of the seal shim **20** can be between, for example, 25 micrometers to 75 micrometers in thickness. The sealant **22** can be, for example, about 12-25 micrometers thick; although, other dimensions are also contemplated by the present invention. In embodiments, a designer would determine the desired gap dimension and select an appropriate seal shim **20** having a thickness that results in the determined gap dimension, taking into account an sealant **22**.

[0027] In FIG. **5***a*, the seal shim **20** is attached to a side **14***b* of the lid **14**, facing the chip carrier **10**. In FIG. **5***b*, the seal shim **20** is attached to a side **10***a* of the chip carrier **10**, facing the lid **14**. In both FIGS. **5***a* and **5***b*, the seal shim **20** can be attached using a sealant **22** such as, for example, silicon, adhesive or epoxy, for example, know to those of skill in the art. In this way, the seal shim **20** will be a permanent part of the multi-chip electronic package. In both FIGS. **5***a* and **5***b*, the seal shim **20** can be self aligned with a protruding portion **14***c* of the lid **14** or an edge **10***b* of the chip carrier **10**, respectively, or using dowels or machined protrusions, as discussed with reference to FIG. **5***c*. The sealant **22** can be dispensed with a fluid dispenser needle with a pressure plunger or auger, as shown at reference numeral **23**. In

embodiments, the seal shim **20** and sealant **22** can be attached prior to or concurrently with TIM.

[0028] In FIG. **5***c*, the seal shim **20** is attached to a side **14***b* of the lid **14**, facing the chip carrier **10**, using a mechanical fastener **24**. The mechanical fastener **24** may be, for example, a screw. The seal shim **20** can be self aligned with the lid **14** by, for example, the use of dowels or protrusions **14***c* machined into the lid **14**, and extending into one or more holes **20***a* of the seal shim **20**. Alternatively, as shown in FIG. **5***c*, the seal shim **14** can be self aligned with the chip carrier **10** by, for example, the use of dowels or protrusions **14***c* machined into the chip carrier **10**, and extending into one or more holes **20***a* of the seal shim **20**. In embodiments, similar alignment mechanisms can be used with regard to the aspects of the invention shown in FIGS. **5***a* and **5***b*.

[0029] In FIG. **6**, the lid **14** and chip carrier **10** are attached to one another with sealant **22**. Prior to encapsulating the chips **12** within the multi-chip electronic package **100**, a TIM **26** is dispensed on the chips **12**. The TIM **26** can be any conventional TIM, and will be placed within the gap "G" formed by the combination of the seal shim **20** and sealant **22** (due to the fact the entire lid (and pistons) are raised from the position of FIG. **3**). As discussed above, the method of the present invention will ensure that there is a uniform thermal gap "G" between each piston **16** and chip **12** for TIM to be dispensed therebetween, regardless of chip height and tilt variation, as the entire lid will be raised above the chip carrier **10**, with the starting point of the piston **16** being in direct contact with its respective chip **12**.

[0030] As shown in FIG. **6**, the seal shim **20** is a permanent part of the multi-chip electronic package **100**. In embodiments, the sealant **22** can be dispensed entirely around the perimeter (or circumference) of the chip carrier **10**. In alternate embodiments, the sealant **22** can be dispensed substantially around the perimeter (or circumference) of the chip carrier **10**, thereby leaving a space for cleaning the interior of the multi-chip electronic package **100**.

[0031] FIGS. **7***a*-**7***d* show several exemplary arrangements and configurations of the seal shim **20** on the lid **14** or the chip carrier **10**. For example, as shown in FIG. **7***a*, the seal shim **20** can be provided about the entire perimeter (circumference) "P" of the lid **14** or chip carrier **10**. As shown in FIG. **7***b*, the seal shim **20** can be provided about the short sides "SS" of the lid **14** or chip carrier **10**. As shown in FIG. **7***c*, the seal shim **20** can be provided about long sides "LS" of the lid **14** or chip carrier **10**. As shown in FIG. **7***d*, the seal shim **20** can be provided at corners "C" of the lid **14** or chip carrier **10**. As should be recognized by those of skill, the arrangements and configurations of FIGS. **7***a*-**7***d* are merely exemplary, and that other arrangements and configurations are also contemplated by the present invention, as represented by FIGS. **7***a*-**7***d*. For example, the seal shim **20** can be segmented along any or all sides of the package, or can be placed between the chips **22** (as shown in FIG. **7***d*). The seal shim **20** can be spheres placed within the seal material **22**, or can be other shapes such as those shown in cross section in FIG. **8**.

[0032] FIG. **8** shows cross sectional views of seal shims **20** used in the multi-chip electronic packages in accordance with aspects of the present invention. For example, the seal shims **20** can be square, rectangular, spherical (oblong), cylindrical (oblong), triangular or pentagon shaped, to name a few.

[0033] The method as described above is used in the packaging of integrated circuit chips. The integrated circuit chips can be distributed by the fabricator in raw wafer form (that is, as a single wafer that has multiple unpackaged chips), as a bare die, or in a packaged form. In the latter case the chip is mounted in a single chip package (such as a plastic carrier, with leads that are affixed to a motherboard or other higher level carrier) or in a multichip package (such as a ceramic carrier that has either or both surface interconnections or buried interconnections). In any case the chip is then integrated with other chips, discrete circuit elements, and/or other signal processing devices as part of either (a) an intermediate product, such as a motherboard, or (b) an end product. The end product can be any product that includes integrated circuit chips, ranging from toys and other low-end applications to advanced computer products having a display, a keyboard or other input device, and a central processor.

[0034] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0035] The corresponding structures, materials, acts, and equivalents of all means or step plus function elements in the claims, if applicable, are intended to include any structure, material, or act for performing the function in combination with other claimed elements as specifically claimed. The description of the present invention has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the invention. The embodiment was chosen and described in order to best explain the principals of the invention and the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated. Accordingly, while the invention has been described in terms of embodiments, those of skill in the art will recognize that the invention can be practiced with modifications and in the spirit and scope of the appended claims.

What is claimed:

1. A method, comprising:

contacting pistons of a lid with respective ones of chips on a chip carrier;

separating the lid and the chip carrier and placing at least one seal shim on one of the lid and chip carrier, the at least one seal shim having a thickness that results in a gap between the pistons with the respective ones of the chips on the chip carrier;

dispensing thermal interface material within the gap and in contact with the chips; and

sealing the lid to the chip carrier with the at least one seal shim between the lid and the chip carrier.

2. The method of claim **1**, further comprising aligning the pistons of the lid in registration with chips on the chip carrier.

3. The method of claim **1**, further comprising planarizing the pistons with a surface of the lid and fixing the pistons to the lid.

4. The method of claim **3**, wherein the fixing the pistons to the lid includes cooling solder such that the solder bonds the pistons to the lid.

5. The method of claim **4**, wherein the contacting comprising placing the lid and chip carrier in a reflow furnace and heating the solder to release the pistons from the lid.

6. The method of claim **1**, further comprising sealing the at least one seal shim to the one of the lid and chip carrier with a sealant.

7. The method of claim **1**, further comprising sealing the at least one seal shim to the lid with a mechanical fastener.

8. The method of claim **1**, further comprising aligning the at least one seal shim with the lid with a dowel extending from the lid.

9. The method of claim **1**, further comprising aligning the at least one seal shim with the lid with machined protrusions extending from the lid.

10. The method of claim **1**, wherein the at least one seal shim is placed at corners of the lid.

11. The method of claim **1**, wherein the at least one seal shim is fixed to the one of the lid and the chip carrier prior to dispensing of the thermal interface material.

12. The method of claim **1**, wherein the contacting is a direct contact.

13. The method of claim **1**, wherein:

the pistons of a lid are placed in direct physical contact with the respective ones of chips on a chip carrier, prior to the placing of the at least one seal shim;

the pistons are fixed to the lid in a position in which the pistons were in direct physical contact with the respective ones of the chips;

a surface of the lid is planarized to a surface of the lid, which is opposing a surface which was in direct physical contact with the respective ones of the chips;

determining a gap dimension and selecting an appropriate at least one seal shim having a thickness that results in the determined gap dimension; and

the sealing the lid to the chip carrier with the at least one seal shim includes using a sealant.

14. A method, comprising:

placing a lid and chip carrier in proximity to one another such that pistons of the lid are in registration with chips on the chip carrier;

contacting the pistons of the lid with respective ones of chips on the chip carrier;

moving apart the lid and chip carrier;

attaching at least one seal shim to the lid or the chip carrier which, when the lid and chip carrier are attached to one another, form a gap between the pistons with the respective ones of the chips;

dispensing thermal interface material within the gap after the attaching of the seal shim; and

sealing the lid to the chip carrier with the at least one seal shim between the lid and the chip carrier.

15. The method of claim **14**, further comprising planarizing the pistons with a surface of the lid after the pistons contact the respective ones of the chips, and fixing the pistons to the lid.

16. The method of claim **14**, wherein the fixing the pistons to the lid includes one of:

cooling solder to the pistons and to the lid; and

applying an adhesive to the pistons and the lid.

17. The method of claim **14**, wherein the contacting comprising placing the lid and chip carrier in a reflow furnace and heating solder to release the pistons from the lid.

18. The method of claim **14**, further comprising sealing the at least one seal shim to the lid and chip carrier with a sealant.

19. The method of claim **14**, further comprising attaching the at least one seal shim to the lid with a mechanical fastener.

20. A structure comprising:

a lid encapsulating at least one chip mounted on a chip carrier;

at least one seal shim fixed between the lid and the chip carrier, the at least one seal shim forming a gap between the pistons of the lid and respective ones of the chips; and

thermal interface material within the gap and contacting the pistons of the lid and respective ones of the chips.

* * * * *